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ABSTRACT

Guidelines are presented for the development of computer-based instructional materials. Steps in courseware development defined by M. D. Roblyer (1988) include: (1) instructional design; (2) preprograming development; and (3) programing. The emphasis is on instructional design, the most time-consuming part of the task. Preprograming development and the actual programing convert the planning to courseware. The first step in instructional planning involves identifying overall instructional content, objectives, and conditions of the course. Once a general course sequence (such as elaboration, inquiry learning, or discovery learning) is identified, task analysis can begin to identify: learning hierarchy; student model; and instructional environment. The second phase of instructional design includes developing individual lessons based on the parameters from the first phase. The instructional set is designed, and teaching strategies are determined. Performance eliciting and assessing is a third step, which must include effective techniques for providing appropriate feedback. The fourth step involves consideration of issues specific to computer-based instruction, such as: learner control; anxiety reduction; cuing; mnemonics; and personalization. A 48-item list of references is included. (SLD)

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Research Based Guidelines for

Computer Based Instruction Development

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Introduction

Computers have become commonplace in schools over the last decade and have arguably been accepted by educators and the general public as an asset of the educational process. In the 1970's, software companies, in their efforts to quickly meet consumer demands, produced proliferate amounts of software that was substandard because it was rarely designed to meet the needs of educators and students. Consumers have tolerated this substandard courseware but have begun demanding quality products that are based on proven instructional design theories and research. Software companies and developers must answer this call for quality to overcome negative attitudes created by the initial wave of inferior software as well as facilitate acceptance and integration of a second wave of high quality courseware grounded in sound instructional design theories and empirical research.

Educational courseware has also begun to benefit from the relatively recent technological development of laser discs. Quick access to any portion of a film by interfacing a computer with a laserdisc player is an effective way to bring short portions of moving pictures to instructional environments for illustrations formerly limited to text or static pictures. Other possible uses for laserdiscs include illustrating experiments or activities that would otherwise be too dangerous, inaccessible or prohibitively expensive. While there is no substitute for the "real thing," viewing an event on film is perhaps next best.

Interactive video is quickly gaining acceptance by the educational community but is subject to the same problems suffered by non-video computer assisted instruction (CAI). Because

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laserdisc technology has only recently found its way into the classroom, there is very little research to guide interactive video courseware development. However, since interactive video is simply another way to present information to computer users, courseware developers utilizing laserdiscs can draw on the experience gained by researchers involved in the development and evaluation of educational courseware and instructional design theorists.

Courseware Development

Roblyer (1988) defines courseware development as a three-stage process which should lead to educationally sound computer based learning products: (a) instructional design, (b) pre-programming development, and (c) programming. The central tenant is to fully develop the instructional method and the lessons(s) before the actual programming takes place. The first stage--instructional design--is the process by which all aspects of the learning task are identified and planned in four stages: (a) general course specifications--identifying overall objectives, determining course sequence and conducting task analyses; (b) lesson design--defining the instructional set and teaching strategies; (c) student performance--eliciting and assessing performance and feedback principles; and (d) other design issues--learner control guidelines and some miscellaneous teaching tools. Completing the four rigorous steps in this first stage will clearly define all predictable aspects of the learning task, leaving only the actual programming which is divided into the second and third stages of courseware development: preprogramming development and programming. It should be emphasized that most of the components in the instructional design stage are applicable to all instructional design tasks, regardless of the delivery medium. Computer technology may be an efficient and versatile tool for teaching; but, because it is a teaching tool, all computer-based instruction must be governed by the same theory and research guidelines which govern all teaching tasks.

Instructional Design

General Course Specifications

Identifying the Overall Instructional Content, Objectives, and Conditions

The first step in designing effective instruction--general course specifications--may seem simplistic, particularly when many times the content is predetermined. But, the systematic

instructional design process must begin by clearly defining the content, broad course objectives, and the conditions that may affect knowledge acquisition (Gagne & Briggs, 1979; Landa, 1983; Roblyer, 1988). The product of this first level analysis will be general, but it should contain specifications sufficiently detailed for further course development, yet should not include individual lesson details. For example, it would be impossible for course designers to know what to include if a course content were specified simply as music theory for high-school students or eighth-grade math. For the music theory course, the content specification should include particular components of the course such as familiarity with major and minor scale structure, range of intervals and types of triads and inversions.

Overall course objectives will be developed from the general content specifications. However, it is not adequate to merely examine the material to be taught: rather, it is extremely important to determine what the learner will be able to do as a result of the instruction (Wager & Gagne, 1988; Roblyer, 1988). Using the music theory class again, examples of broad objectives based on the given content specifications are: (a) writing and performing major and minor scales, (b) reading and writing intervals and triads, and (c) recognizing intervals and triads when played.

Defining the content and objectives should draw the developer's attention to some of the target audience's characteristics (Carrier, 1988) so that the instruction can address the specific nature of the students (Landa, 1983): if the music theory students are also instrumentalists, the course developers will be better able to develop appropriate objectives by taking into account conditions such as instructional delivery tools with which students are familiar, performance media used by the target audience, and the teaching environment.

Course Sequence Based on Overall Type of Learning

Once the content is defined and broad objectives developed, the next step is to determine the overall course structure, sometimes called macro structures (Merrill, 1983). An overall plan that is appropriate for the subject matter and target audience will be the product of this step rather than particular teaching strategies. (Detailed teaching strategies will be identified and discussed at the lesson development stage.) Three basic course structures encompass nearly all instructional designs: (a) elaboration, (b) inquiry learning, and (c) discovery.

Elaboration

Elaboration refers to nearly all types of instructional sequences in which an initial, easily understood, concept or attainable goal is taught as a starting point for subsequent concept acquisition or skill development. The instructional designer should decide what sort of sequence and starting point will be the most effective. Most designs follow a simple to complex pattern (Collins & Stevens, 1983; Gropper, 1983; Reigeluth & Stein, 1983; Scandura, 1983), but the progression may differ slightly such as beginning with concrete concepts and progressing to abstract concepts (Collins & Stevens; Gropper) or meaningful to less meaningful concepts (Aronson & Briggs, 1983). The snowball method (Landa (1983) is another possible overall course structure based on mastery: The simplest or initial component is learned and mastered, after which the next step or concept is presented followed by the next until the instructional goal has been reached.

Inquiry Learning

Inquiry learning refers to a learning environment in which students begin with given, student developed, synthesized or alternative hypothesis (Collins & Stevens, 1983) and are guided through a process to prove, modify, or disprove the initial hypotheses. Inquiry learning is more structured than discovery learning, yet allows deeper processing than many of the elaboration types of instructional sequences.

Discovery Learning

Discovery learning differs from inquiry learning in that no hypotheses is presented at the beginning of instruction. The students interact with their learning environment to discover, or rediscover, principles and concepts. Discovery learning is often the best method for learning, but is nearly impossible because of the conditions imposed on contemporary learning institutions such as time constraints, limitations on materials, and teacher/pupil ratios (Landa, 1983). Landa suggests a mix of discovery learning and standard methods by providing a discovery experience to teach students how to discover algorithms and then present situations in which the algorithms can be applied, but does not recommend an optimal time for each.

Task Analysis

The course content has been identified, broad objectives developed, and a target audience generally defined. From this initial information, a general course sequence such as elaboration, inquiry learning, discovery learning or a combination of one or more was selected and the next step--task analysis--can commence.

Task analysis is a rigorous process of breaking the instructional content and the conditions affecting its acquisition into their smallest constituent parts (Aronson & Briggs, 1983; Carrier, 1988; Landa, 1983; Roblyer, 1988) and includes five interrelated domains: (a) learning hierarchy, (b) student model (c) instructional environment, (d) detailed objectives and (e) performance/content specifications. The parameters returned by analyzing these five domains will help the instructional designers accurately locate the appropriate starting point for learning, or the largest manageable chunk of information the intended audience can assimilate without causing cognitive overload (Landa). The integral approach to classroom teaching assumes teachers can conduct individualized and adaptive instruction according to the needed level of simplicity (Landa), but computer-based instruction must be able to accommodate an audience that can only be estimated. The task analysis domains are recursive in actual instructional development, but they are discussed more easily separately. The first three: (a) learning hierarchies, (b) student model, and (c) instructional environment are the components that, when combined, identify the point in the learning hierarchy that delineates the prerequisite skills and concepts it is assumed the learners possess and the prerequisite skills and concepts the learners do not possess. The final domains--(d) detailed objectives and (e) performance/content specifications--are interdependent and determine specifically what concepts, skills, and goals will constitute the actual instruction.

Learning Hierarchy/Prerequisite Skills

A learning hierarchy is the product of an analysis in which the final learning outcomes are broken down into their smallest prerequisite parts in one of two ways: (a) a list or group of the prerequisite parts that does not reflect the order in which they should be taught (Aronson & Briggs, 1983; Gropper, 1983; Hannum, 1988) and (b) a sequential list that does reflect the order in which the parts should be taught to lead to the final outcomes (Gropper; Hannum). Although Gagne and Briggs (Aronson & Briggs) state that a learning hierarchy should be applied only to intellectual

skills, others indicate that such a hierarchical structure can be applied to any learning task that needs to be taught via a progressive presentation of its prerequisite parts (Gropper; Hannum; Landa, 1983).

The learning hierarchy is the major component used by instructional designers to determine what skills and concepts need to be taught. Based on the student and instructional environment models, the target audiences' starting state--the point on the hierarchy below which it is assumed that the prerequisite skills are in the learners' repertoire and above which learning must take place--can be located as accurately as possible (Aronson & Briggs, 1983; Gropper, 1983).

Student Model

The instructional design process must specify the nature and characteristics of the students to be transformed (Landa, 1983) including the prerequisite skills already in their repertoire (Roblyer, 1988). The more prior knowledge students have, the higher they will fall in the learning hierarchy, making assimilation of new knowledge easier (Carrier, 1988). It is also important to determine what factors are needed to make the courseware interesting to them (Keller & Suzuki, 1988). The courseware should adapt to learners' interests (Montague, 1988) by matching student characteristics with the delivery mode through pretests or embedded questions in addition to research about similar audiences (Carrier). The student model is indispensable for creating computer-based courseware that accurately accommodates the target audience for effective and efficient instruction.

Instructional Environment

Although the learning hierarchy has been completed and the target audience identified or specified, there is a third area--instructional environment--that needs attention (Roblyer, 1988). The instructional environment is composed of factors that may further influence the designers choice of teaching strategies or selection of relevant prerequisites. These factors include (a) tools available for instruction, (b) possible problems that may be encountered delivering the instruction including (c) safety and attainability of final goals.

Tools. Examples of tools are science equipment, math manipulatives, and computer hardware. Learning environment considerations often concentrate on what resources are not available or what outcomes are not attainable, which force instructional designers to consider less

true experiences (Gropper, 1983). However, the opposite is also true: if a tool is available that has the potential of providing experiences not otherwise attainable then it too can influence the decisions of instructional designers. One important tool that is becoming more common in schools is the microcomputer which has the potential of providing close representations of reality otherwise unobtainable, particularly when interfaced with a laser disc player. Although courseware is requiring more and more sophisticated hardware, designers still must often make decisions between what is available and what is needed. While simple drill and practice programs require very little hardware, increasingly complex and user friendly programs designed to meet user demands require more computing power. With computers, students can experiment with hazardous materials, operate expensive and dangerous equipment, and pursue learning experiences with live subjects through simulations--experiences that justify the expense of expanded computer facilities.

Therefore, the subject matter will often drive hardware demands: if the courseware teaches about a subject that is most effectively delivered via an as-near-to-real simulation, then a video disc player will be needed. An example might be a program that teaches classroom discipline techniques. A simulated classroom presented by a laser disc may be more effective to instruct and maintain interest than a text based simulation and has the advantage of being available to anyone at anytime.

Problems. Instruction must take into account factors that may hinder the learning process. Examples of problems that may arise include teacher/student ratios, lack of equipment and time constraints. If the instructional setting encompasses one teacher and 30 students, the instructional design cannot specify one-on-one or small group activities. When the environment cannot provide needed materials, the designer must investigate alternative outcomes, whether they are different outcomes or alternate representations of reality. For example, if a school simply does not have the money required for equipment and supplies to perform the experiments called for in the science curriculum, alternative outcomes or procedures must be explored. When the procedures required by learning outcomes are too time consuming, the designers will be forced to consider ways to compress real time in order to meet curricular demands.

Safety and attainability. Before in-depth instructional design begins, another task that may need consideration is examining the intermediate and final goals for safety and/or attainability (Gropper, 1983): The desired goals may simply be too dangerous for performance due to (a) the use of dangerous equipment or substances or (b) the hazards and difficulties inherent in working with human or animal subjects. It should be clear that experimenting with dangerous chemicals, and equipment is not an option for many instructional settings nor is it very often possible to conduct initial learning involving humans and animals with live subjects.

Learner Starting Point

Completing the task analysis enables the instructional designer to accurately identify the point at which instruction should begin by (a) breaking the learning tasks into their composite prerequisite chunks and locating the appropriate instructional starting point on the resultant hierarchy of prerequisite skills based on parameters specified by the (b) student model in which specific characteristics of the target audience are identified and (c) instructional environment which specifies the availability or unavailability of tools and equipment as well as possible problems such as large teacher/student ratios, time constraints and safety of goal realization. The student model and instructional environment model may also have caused some reevaluation and modification of the original learning hierarchies in order to overcome real or potential obstacles.

Prerequisites. The "point" at which the learning hierarchy is neatly divided to define the starting point for instruction is actually quite ambiguous. When learning outcomes are broken down into learner manageable chunks, the resulting list actually constitutes three prerequisite skills classifications rather than the two previously discussed: (a) prerequisite information that everyone in the target audience knows, (b) prerequisite information that only some know and (c) information that no one knows (Hannafin & Peck, 1988). Ideally the information that everyone knows and the information only some know can be disregarded, and the information no one knows will constitute the body of instruction (Hannafin & Peck). However, in practice, the prerequisite skills that only some know become important to the success of the lesson. It is rare to locate a clearly defined starting point for an individual learner and virtually impossible for a group, particularly when courseware is designed to meet the needs of an audience whose characteristics can only be

estimated. Therefore, the true starting point actually falls within a range, bracketed by the information everyone knows and the information no one knows.

It should be clear that instruction needs to be versatile enough to address variable audiences by customizing presentations to meet the needs of individuals--something professional classroom teachers do everyday as a matter of course based on their knowledge of their students. Classroom teachers also recognize a zone of prerequisites that they expect all their students to know, and a zone that none of them know, but their customized starting points fall in the middle zone--information only some of the learners know. Computer based instruction is incapable of knowing exactly where learners are in the learning hierarchy and must therefore be capable of beginning instruction at a variety of points. Fortunately, this capability is one of the primary advantages of computer based instruction. Courseware can easily be designed to meet the needs of a widely varied audience by offering various entry levels. The techniques may be as simple as a student/teacher chosen level in an opening menu or a computer chosen level based on a pretest. More complex user level choices are determined by the computer based on learner responses to pretests, interim tests and embedded questions.

The instructional designer is now ready to engage the last pre-delivery design step--specification of detailed objectives including subject matter types and the levels of cognitive engagement needed to process each objective.

Detailed Objectives and
Subject Matter/Level of Cognitive Engagement Specification

The last step that must be completed before actually designing the individual lessons that lead to the final outcomes is to convert the list of prerequisite skills to be delivered (all those above the starting point on the learning hierarchy) into detailed objectives complete with subject matter type specifications and the level of cognitive engagement required to adequately process the new information (Gagne & Briggs, 1979; Roblyer, 1988). Subject matter type refers to the abstractness of the objective--is it simply a fact or is it a principle governing abstract concepts? The level of cognitive engagement refers to the type of processing needed to assimilate the new information--does the objective merely require remembering something or does it require formulation? Some theorists make only a distinction between (a) learning to follow directions to

accomplish a goal and (b) learning the theory behind actions or knowing why certain things are done to reach a goal (Landa, 1983). A similar distinction is between (a) teaching particular rules or theories and (b) teaching how to derive or discover rules or theories (Collins & Stevens, 1983). Gagne elaborates on these two categories by breaking them into five widely used types of learning objectives--(a) intellectual skills, (b) cognitive strategies, (c) verbal information, (d) motor skills and (e) attitudes. The first type--intellectual skills--is further divided into (a) concrete concept, (b) defined concept, (c) rules, (d) higher order rules, and (e) problem solving (Aronson & Briggs, 1983; Gagne & Briggs, 1979; Wager & Gagne, 1988). Merrill (1983; 1988) also elaborated further and developed one of the most complete classification methods--the performance/content matrix--that categorizes (a) levels of cognitive processing or performance and (b) types of skills or subject matter. The performance/content matrix is composed of three types of performance--(a) find, (b) use, and (c) remember and four types of subject matter--(a) facts, (b) concepts, (c) procedures, and (d) principles (*See figure one).*

Performance. Performance refers to the depth of cognitive engagement needed to process information. Remembering is simply rote recall (Landa, 1983) of facts or principles, which is similar to Gagne's verbal information (Aronson & Briggs, 1983; Gagne & Briggs, 1979; Wager & Gagne, 1988), Landa's (1983) algorithmic learning, and Collins and Stevens (1983) teaching students particular rules or theories. Remembering is the only performance type that can be applied to facts (Merrill, 1983). Use is the next level of cognitive engagement and can be applied to intellectual skills (Aronson & Briggs) and applying explanations to given subjects (Gropper, 1983). The top level--find--is similar to Gagne's cognitive strategies (Aronson & Briggs) and is learning how to derive rules or theories (Collins & Stevens).

Content. Content, or subject matter refers to the abstractness of the concept. The first content category--facts--is (a) classifying objects, events, or states using verbal descriptions or definitions, (b) identifying instances of the concept by pointing to examples or (c) discriminating between various stimuli (Aronson & Briggs, 1983). The second performance type--concepts--is demonstrating the application of particular rules (Aronson & Briggs; Collins & Stevens, 1983). The third category--procedure--requires synthesis and discovery by learners as they generate new rules for solving problems (Aronson & Briggs; Collins & Stevens; Landa, 1983). The highest

level of cognitive engagement--principles--also requires discovery and synthesis as learners derive principles and theories about the subject matter (Collins & Stevens).

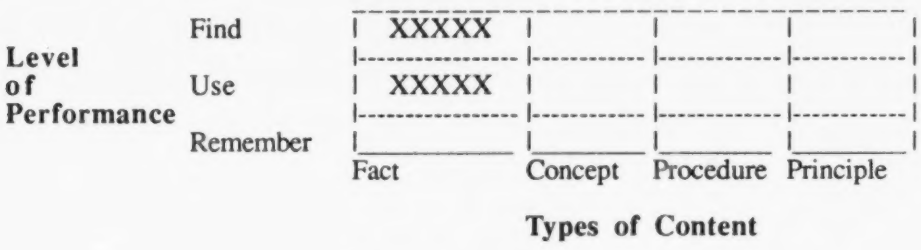

Fig. 1. Merrill's Performance-Content Matrix.

Since the subject matter classifications can be applied to all four performance categories and vice versa, Merrill presents them in a matrix (*see figure one*) resulting in a total of ten performance/content classifications (find and use cannot be applied to facts). Classifying all instructional objectives according to one of these categories will help designers select appropriate methods for instructional presentation that will lead to the most efficient acquisition of final learning outcomes (Aronson & Briggs, 1983; Merrill, 1983).

Lesson Design

The second phase of the instructional design stage is developing individual lessons based on the parameters determined in the first phase. Suitable teaching strategies that have been developed by instructional design theorists and supported by empirical research must be selected. A framework for successful courseware development is Gagne's nine events of learning (Reeves, 1986). Briefly, this method identifies nine distinctive events that must be completed for learning to occur: (a) gaining attention, (b) informing the learner of the lesson objective, (c) stimulating recall of prior learning, (d) presenting stimuli with distinctive features, (e) providing learning guidance, (f) eliciting performance, (g) providing feedback, (h) assessing performance, and (i) enhancing retention and learning transfer (Wager & Gagne, 1988). Although the nine events are normally used as a prescription for teaching individual concepts, with minor adaptations, they also provide a logical framework for discussing various instructional design techniques and teaching strategies.

The events will be grouped into four domains: **(a) instructional set, (b) teaching strategies, (c) student performance,** and **(d) issues unique to computer-based instruction.** Because the discussion focuses on general strategies for all aspects of instructional design one change will be made: the ninth event--enhancing retention and learning transfer--will be included in the second phase--teaching strategies--because the techniques for enhancing retention and generalization are actually teaching strategies.

Instructional Set

Instructional set is the stage in which well designed instruction prepares the learners to engage the forthcoming new information. This stage consists of Gagne's (1975) first three events of learning: (a) gaining the learners' attention, (b) informing learners of the objectives, and (c) stimulating recall of prior learning. For the purpose of discussing various strategies useful to courseware designers, the second event--informing learners of the objectives--has been changed to orienting activities which includes various types of activities intended to predispose learners to upcoming instruction. The third event--stimulating recall of prior learning (previously acquired prerequisites) has been expanded to include techniques for supplying missing prerequisites.

Gaining Attention

Gaining the learners' attention is causing the student to become cognizant of the lesson's purpose. Doing so may require as little as presenting a title or as much as presenting a situational description or visual stimuli representing the courseware content (Wager & Gagne, 1988). Students who are already aware of the purpose of the lesson and are seeking instruction do not need their attention gained, whereas other students may need to learn something about the upcoming lesson before feeling the need to pursue it. It is important to present the forthcoming lesson in a manner in which the student will realize the importance of learning the skill, therefore making the learning task relevant to them, which helps motivation (Keller, 1983; Keller & Suzuki, 1988). Courseware should also present explicit directions for using the program to facilitate specific learner processing (Jonassen & Hannum, 1987).

Orienting Activities

(Informing Learners of Objectives)

Informing learners of objectives has been changed to orienting activities to include various techniques that can be employed at the beginning of computer based learning activities to relate upcoming learning to the learner's present knowledge and mental state (Jonassen & Hannum, 1987; Wager and Gagne, 1988). Orienting activities include (a) pre-questions, (b) informing the learners of expectations, and (c) advance organizers. When well designed, orienting activities should function in motivational and cognitive enhancement capacities.

Motivation

Orienting activities can provide motivation to students by presenting an overview of the lesson including expectancies for success with which learners can decide whether or not the goals are obtainable and thus worth working toward. If learners perceive themselves capable of successfully completing or even working toward the prescribed skill, they will be motivated to do so (Keller, 1983; Keller & Suzuki, 1988). Orienting activities can also reduce learner anxiety about the program and therefore create a more relaxed mental state in which learning can more easily take place (Hannafin, Garhart, Rieber & Phillips, 1985). On the other hand, it may not be desirable to include orienting activities for motivational purposes if students may already be highly motivated by some external event and are seeking the skills the courseware has to offer, rendering such motivational pre-activities worthless or even bothersome (Gagne, 1986).

Cognitive Enhancement Devices

Besides motivation, orienting activities can enhance learning by prestructuring the learners' mental set for the upcoming cognitive activities. It has been shown that non-specific but relevant pre-questions before (and after) learning activities will help facilitate new higher order structures, far transfer, and generalization (Anderson, Spiro & Anderson, 1978; Hamilton, 1985).

Informing the learner of expectations (general, specific, or both) activate related items in long term memory which then help activate the learners' "mental set" (Gagne, 1975, p. 94) which in turn enables them to assimilate the new information causing it to be more meaningful (Gagne & Briggs, 1979; Hannafin & Hooper, 1989). In an interactive video lesson utilizing the *National Art Gallery* video disc to teach about artists and contemporary influences at the graduate level,

students required about 20 seconds to process orienting questions in order for them to be helpful in attaining higher achievement levels (Hannafin, Phillips & Tripp, 1986).

Another way to orient learners is to present the lesson objectives before they begin working with the content. Students who have been presented with objectives at the beginning of a lesson may be more inclined to review major points because they will have formed a basis upon which the metacognitive skill self-review is stimulated (Ho, Savenye & Haas, 1986). In a review of computer-based reading research, Blanchard (1987) found that low-achieving students need instructional objectives to help motivate learning and develop desirable reading skills.

There are some examples and instances in which orienting activities are not desirable or are superfluous. Mayer (1984) argues that orienting activities are not necessary if the lesson is well sequenced but do not do any harm if they are present. In another interactive video lesson on art and art history for undergraduate students, the inclusion of orienting questions made no difference in student achievement (Phillips, Hannafin & Tripp, 1988). However, if the target audience is highly skilled, forcing a structure upon them may actually inhibit learning. Students involved in an unstructured interactive video lesson on identifying water fowl were blocked according to their preconceived notions of how they were going to learn the task. Those students who had a good concept of how they were going to learn out-performed the students who did not (Gay, Trumbull & Smith, 1988). Therefore, imposed strategy may impede students who have a pre-formed notion of learning.

These guidelines indicate that courseware directed at a widely varying audience should include orienting activities. But since some learners may not need them, or might even be impeded by them, quality courseware should include an option to bypass them when appropriate.

Stimulating Recall of Prior Learning and Supplying Missing Prerequisites

Before a new concept can be learned, it is often necessary to stimulate students' recall of previously learned prerequisite skills and must take place before learning can begin (Aronson & Briggs, 1983; Reigeluth & Stein, 1983; Wager & Gagne, 1988). These prerequisite skills encompass any knowledge or skills that are necessary for learning the present task that the students should already know--all skills that fall below the target audience's present position in the learning

hierarchy. This point is the starting state at the beginning of instruction and the current position in the hierarchy after instruction begins.

This learning event--stimulating recall of prior learning--has been expanded to include supplying missing prerequisites. One of most common problems with classroom instruction is accurately pinpointing the correct starting state of learners because rarely does a group of students enter a learning situation with the same amount and type of knowledge. This problem can be compounded when computer based courseware developers try to create effective instruction for audiences whose needs can only be estimated. However, this is a problem for which computers are uniquely suited to solve. Computer courseware can be constructed to meet the needs of a widely varied audience by containing a usable learning hierarchy that encompasses the needs of students with differing levels of prerequisite skills. Usable learning hierarchy refers to the option of entering the learning task at whatever level is suited to each user based on some sort of starting state assessment. This assessment might be an activity level specified by an instructor or the student, or, in more advanced software, based on an online pretest or student supplied answers to embedded questions. Furthermore, during the learning task, if the student, teacher, or program determines that some prerequisite skill is missing, the computer can easily supply whatever is needed. For example, if a student using a chemistry simulation repeatedly makes the same mistake regarding a certain chemical, the program, based on the student's answers or by request, can branch to a tutorial section about that particular item and then return to the main program.

Teaching Strategies

The instructional designer has now reached the point at which the learner is prepared to learn. This section of the instructional delivery phase consists of three events: (a) presenting stimuli with distinctive features, (b) providing learning guidance, and (c) enhancing retention and transfer. These three events encompass the juncture at which the learner receives information specified by the individual objectives and makes a mental model of the information, sometimes called the cognitive stage (Salisbury, 1988).

Presenting Stimuli With Distinctive Features

Presenting stimuli with distinctive features has two perspectives: (a) pedagogical--what aspect of the material is presented to the learner initially and (b) technical--the appearance of the initial concept.

Pedagogical

A lesson must start somewhere and the first objective presented must have distinctive features if the learner is to understand and be interested in all that will follow. Although the first objective goes by many names (e.g.; exemplar, epitome and paradigm), perhaps the most common guideline is to keep it simple (Aronson & Briggs, 1983; Collins & Stevens, 1983; Gropper, 1983; Reigeluth & Stein, 1983; Scandura, 1983). Other recommendations are for the initial presentation to be meaningful or relevant (Aronson & Briggs; Keller, 1983; Keller & Suzuki, 1988) and concrete (Collins & Stevens; Gropper) depending on the nature of the subject. If the lesson is attempting to teach attitudes then it is important to choose a positive role model for the initial presentation (Keller; Keller and Suzuki).

Technical

Presenting stimuli with distinctive features also refers to the manner in which information is presented on the computer screen. The appearance of text and graphics, as well as the manner in which the student's attention is focused on particularly important points should be considered. The primary recommendation is to keep the screen as simple and uncluttered as possible. Presenting too much information at one time can be confusing and overwhelming. The use of color and text formatting (e.g., inverse print, underlining, shading, arrows and flashing) can be effective but should be carefully considered. Flashing should never be used for text presentation because it is distracting and difficult to read (Jonassen & Hannum, 1987).

Color is most effective when it is used consistently for cuing and highlighting to direct student attention to important points or relationships (Merrill, 1983; Merrill & Bunderson, 1979). Also, color should be used as sparingly as possible because the more color that is used, the less effective it becomes (Kanner, 1968). Studies have found that color cuing helps low achievers learn more, but can hinder high achievers' learning (Hativa & Teper, 1988).

Providing Learning Guidance

Now that the initial concept has been presented, the courseware designer must determine how subsequent information will be presented to the learner and the manner in which the program will direct the learning process. There are three basic instructional strategies for attaining each objective on the appropriate learning hierarchy (which are the same as for overall course sequencing): (a) elaboration, (b) inquiry learning, and (c) discovery learning. The three strategies may be thought of as falling on a continuum on which elaboration strategies represent the least processing required by the student and discovery learning represents the most. Deeper levels of processing or assimilative processing causes new information to be better encoded in the learners' memory (Jonassen, 1988). Therefore, effective instruction should combine facets of all three strategies, but most often include only elaboration and inquiry techniques due to instructional environment constraints. If the original learning hierarchy was not prioritized according to an anticipated learning sequence (Aronson & Briggs, 1983; Wager & Gagne, 1988) it must be done before instruction begins. The next section briefly describes each of the three instructional methods as they might apply to computer courseware development, followed by various teaching techniques or tools that may be applied to any one of the three.

Elaboration

Instructional sequences that teach concepts by initially presenting a basic, understandable idea and move progressively towards the more complex aspects of concepts can be subsumed by the general term elaboration. Although all elaboration sequences follow a basic-to-complex progression, there are four common types, one of which should be selected according to the subject matter. It should also be congruent with the type of initial presentation chosen in the previous step. The most universal specification is the general, non-specific simple-to-complex sequence (Collins & Stevens, 1983; Gropper, 1983; Scandura, 1983; Reigeluth & Stein, 1983) and includes backward chaining. More specific designations are the concrete-to-abstract design (Collins & Stevens; Gropper; Jonassen & Hannum, 1987), meaningful-to-less-meaningful progression (Aronson & Briggs, 1983; Keller & Suzuki, 1988; Salisbury, 1988) and important-to-less-important (Collins & Stevens).

Inquiry Learning

Because posing questions and guiding students into question generation promotes more learning of skills stated in the objectives and increases curiosity (Jonassen & Hannum, 1987; Keller, 1983), most effective instruction combines techniques from elaboration and inquiry. Essentially, in inquiry learning, a rule is stated or a question is posed, and the student is guided to discover evidence to support or disprove the rule, or, discover an answer to the question (as opposed to discovery learning in which no rule is stated initially) (Collins & Stevens, 1983). Also like elaboration strategies, a decision must be made whether to teach students particular rules and principles to follow or to teach them how to derive rules and principles. Several strategies developed by Collins and Stevens are particularly suited to computer based courseware: (a) forming hypothesis, (b) evaluating hypothesis, and (c) tracing contradictions to a conclusion.

Discovery Learning

Discovery learning is usually the best but is almost impossible in most school settings due to time constraints and the difficulty of giving necessary individual instruction (Landa, 1983). If possible, a teacher should provide a discovery experience to teach students how to discover algorithms and then present situations in which the rules can be applied.

Method Independent Techniques for Effective Instruction

Prerequisite skills were previously broken into three categories: (a) skills that everyone knows, (b) skills that some know, and (c) skills that no one knows. Many theorists add a fourth category: (d) supporting prerequisites (Aronson & Briggs, 1983; Gropper, 1983; Hannafin & Peck, 1988; Reigeluth & Stein, 1983). Supporting prerequisites are concepts that are not part of the essential concepts needed to attain the final goals as specified by the learning hierarchy but can be used as supplements. The use of non-requisite skills and concepts is often indispensable for facilitating understanding, creating positive attitudes and maintaining interest and should be an integral part of well designed instruction. The five examples that follow--(a) counter examples, (b) analogies, (c) contextual elaboration, (d) representational elaboration, and (e) knowledge structure enhancers can easily be utilized in computer based instruction.

These strategies have been included under the heading "Method independent techniques for effective instruction" because they should be a part of all instruction, regardless of the chosen instructional design.

Counter Examples. One of the most recommended strategies for illustrating a concept is the use of counter examples when presenting new material (Aronson & Briggs, 1983; Collins & Stevens, 1983; Jonassen & Hannum, 1987; Merrill, 1983). When students consider counter, negative or alternative examples they will gain more diagnostic skills and learn to support their assertions. Therefore, as many positive and negative examples as is needed should be used (Collins & Stevens). The use of counter examples also arouses attention and increases curiosity, although prudence should be exercised when used exclusively for this purpose (Keller, 1983; Keller & Suzuki, 1988).

When utilizing counter examples to teach concepts, care should be exercised to ensure all non-relevant characteristics of the target concept and the counter examples are the same (Merrill, 1983). However, when the task involves discriminating between two items that are nearly identical it may be necessary to exaggerate the difference. For example, when teaching students to distinguish between in-tune and out-of-tune pitches, it might be helpful to make the out of tune pitch very out of tune and work towards finer discriminations (this can also be considered an overall teaching strategy such as Gropper's (1983) shaping). If the learning task involves motor skills, it is often useful to actually try to perform a counter example, or incorrect method to help understand the correct way (Gropper). An example of this technique would be to over-sheet and under-sheet a jib-sail to illustrate the effects of incorrect settings on boat speed. Corrects sail settings should then be easier to understand.

Analogy. Another common technique for teaching is the use of analogies and metaphors (Jonassen & Hannum, 1987; Merrill, 1983) generated by either the computer or the learner (Jonassen, 1988). Analogies help develop new cognitive structures (Hannum, 1988) by making the strange familiar and the familiar strange (Keller, 1983). The use of analogies can be thought of as an elaboration technique, but the difference is that they are not essential prerequisites for the concept(s) being taught. If more than one analogy is available at a given time for the subject matter

at hand, include as many as needed, particularly if there are considerable individual differences among the learners (Reigeluth & Stein, 1983).

Contextual elaboration. Contextual elaboration refers to the context of the material to be learned, the historical background, or some prerequisite information that has not been previously discussed. The purpose is to increase the knowledge and understanding of particular subject matters or to raise the interest level (Merrill, 1983) through helpful but non-essential information (Aronson & Briggs, 1983; Gropper, 1983). These elaborations might be information directly related to the current learning task, or anecdotes and personal stories to increase curiosity and interest which will transfer to the present task (Keller, 1983).

Representational elaboration. Quite often people who do not understand information that is delivered by text will understand when the same information is presented or augmented by various visuals (Merrill, 1983). Also, very difficult topics sometimes become easier to understand when augmented by graphic displays (Gropper, 1983). Courseware can easily present information in text mode or graphics mode but, if possible, should include both. The learner could have a choice between visual and non-visual presentation modes or simply have the option to view additional displays of the opposite mode if desired.

Knowledge structure enhancers. Devices that facilitate an understanding of the relationships between the various concepts being learned are often helpful. Devices can be as simple as asking the learner to create a mental image of the concept just learned (Jonassen, 1988) or a screen generated image (Jonassen & Hannum, 1987). Requesting that the learner think of an analogy or to paraphrase a concept also enhances knowledge assimilation (Merrill, 1983). Another common way to represent knowledge is through cognitive or semantic mapping (Dennenberg, 1988; Hannum, 1988). As learners progress through the learning task, the relationships between concepts can be depicted pictorially by either the computer or the student to help illustrate the overall structure and possibly guide the learning sequence.

Enhancing Retention and Learning Transfer

Enhancing retention and learning transfer is the last step in Gagne's (1975) hierarchy, after eliciting and assessing performance and providing feedback. However, the inclusion of retention and transfer in the teaching strategies section makes sense because of similar techniques and

overlapping procedures when discussing it in terms of overall instructional strategies as opposed to the progression to be followed when delivering a single concept.

Simply gaining a bit of knowledge is not learning. Learning is intended only when relevant practice is provided (Gagne, 1986): A student must be able remember and apply knowledge to the same or similar situations in the future, which is generally accomplished through practice and elaboration (Wager & Gagne, 1988). According to Salisbury (1988), there are two stages after the cognitive state--the point at which initial learning takes place. The first is the associative stage which is a practice stage in which concepts and relationships are strengthened and errors contained in initial concepts are corrected. The second is the autonomous stage in which skills become automatic. Both assimilation and autonomy are achieved through practice.

Varied Practice

Varied practice is essential for promoting generalization and transfer (Gropper, 1983), particularly for the lower performance types--remember and use--because higher level concepts are easier to remember due to the deeper processing required (Merrill, 1983). For the lower skills, learners must have practice distinguishing between examples and non-examples and for higher level skills, opportunities over time to practice creating new solutions (Aronson & Briggs, 1983). If possible, practice should emphasize the practicality of the newly learned concepts or skills in a realistic, situational environment (Montague, 1988; Salisbury, 1988). Gropper also cautions that there should not be too much or too little time between practice: If students have no chance to practice in a four hour presentation, there is little chance they will retain the information.

Research on practice in computer based courseware has been largely positive. In a brief study utilizing the National Art Gallery video disc, Hannafin, Phillips and Tripp (1986) found that practice led to significantly higher scores for factual recall tasks but not for tasks in which learned facts had to be applied to new situations. In a second, similar, study also using an undergraduate sample, practice resulted in higher scores on learned facts and on the application of facts to new information, but the scores on factual information were much higher than the transfer scores (Phillips, Hannafin & Tripp, 1988). In a third but unrelated study using the same National Art Gallery video disc and a college age sample, Jonassen (1988) found that practice and practice plus elaboration groups performed significantly better than the group without practice.

Review

Review is another activity that enhances retention particularly when done prior to testing (Jonassen & Hannum, 1987). An effective review strategy is summarizing which should consist of three parts: (a) a precise statement of each idea and fact that has been taught, (b) reference examples such as typical, easy-to-remember examples, and (c) some diagnostic self-test items for each idea (Reigeluth & Stein, 1983). There are two types of summary activities: (a) internal--which include material contained only in the present lesson and (b) cumulative--which include all material up to and including the current lesson (Reigeluth & Stein). Research shows that students who have the option to review achieve more on concrete concepts than those without the option, but only when objectives are given in the beginning of the lesson (Ho, Savenye & Haas, 1986). An additional finding by Ho, Savenye and Haas is that program controlled review leads to higher achievement for concrete and verbal information and rule learning than no review.

Synthesizers

A form of review that leads to deeper processing and therefore better retention than simply revisiting facts are synthesizers which periodically interrelate and integrate the individual ideas that have been learned. Synthesizers compare and contrast related ideas and show how new ideas fit within the overall knowledge structure to increase meaningfulness and motivation. In general, a synthesizer (a) presents a generality, (b) shows the relationships among the parts and with related ideas, (c) includes integrated reference examples, and (d) provides diagnostic self-test practice items (Reigeluth & Stein, 1983). Summaries and synthesizers are consistent with strategies presented in the knowledge structure enhancers section.

Student Performance

The final events--student performance--take place after the cognitive stage and includes effective techniques for (a) eliciting performance, (b) assessing performance, and (c) providing appropriate feedback. Although performance elicitation and assessment constitute two distinct steps in Gagne's (1975) nine events leading to learning single concepts, the principles guiding them are similar and discussing them separately would result in a large amount of overlap. Therefore, when designing computer based instruction, single unit treatment is advantageous. Although the following guidelines are intended to be applied to interim or final performance

elicitation and assessment situations, they can also be referred to when eliciting performance to enhance learning retention and transfer.

Eliciting Performance and Assessing Performance

Eliciting and assessing performance simply refers to causing students to perform, or respond to questions throughout the instruction (Wager & Gagne, 1988) and making judgments on the quality of the response. A basic premise of cognitive psychology is that an overt response is not needed for learning to take place--an instructor could simply ask the learner to make a self-estimate of their understanding of a concept. However, a response is needed if an external, criterion based assessment is part of the instructional process (Jonassen & Hannum, 1987).

Objective-Performance Match and Active Participation

When responses are carefully designed, they will indicate or represent cognitive change (Scandura, 1983). There are two major principles to guide performance elicitation: (a) require responses that match the level of processing specified by the objective and performance/content category (Gropper, 1983; Jonassen & Hannum, 1987; Merrill, 1983) and (b) active participation is superior to reactive (Jonassen & Hannum). Each objective should be evaluated to determine the number and type of questions needed for accurate assessment: (a) The simplest type of task--rote recall items--require only one question, possibly more if paraphrasing, (b) the next level--use, or application tasks--require as many as needed to cover all aspects of the objective, and (c) deep processing tasks--find, or synthesize--usually dictate the type and quantity of questions (Merrill). A concept should be tested at all three levels in order to be truly learned (Merrill). For example, if the lesson teaches about chords, the student should be able to remember what the characteristics of a particular triad are, use those characteristics to build their own examples and be able to find different ways a particular chord is used in a piece of music and recognize variations.

Performance Realism, Time Allocation, and Acceptable Standards

When eliciting and assessing performance, students should be required to perform in conditions that are the same as or closely represent the situation in which the skill is normally required, under conditions that typically affect them (Gropper, 1983; Montague, 1988; Salisbury,

1988). Merrill (1983) recommends that the time allowed for answering should increase as the level of cognitive processing deepens: For verbatim recall there should be no time delay, higher level tasks require some time, and find and synthesize tasks should have no time limit. Performance demands should be within the learners' reach based on their present position in the learning hierarchy in order to enhance achievement-striving behavior (Keller, 1983). Therefore, lesser standards are acceptable at early stages (Gropper; Hannafin & Peck, 1988). Another idea is using learning deficits as motivational incentives (Ross & Morrison, 1988): Based on pretest assessments, concepts about which learners know less could be worth more in later testing situations.

Instrument Reliability and Validity

Another item of importance is the verification of test questions. When computer-based instruction is designed for large group applications, establishment of reliability and validity of each test question to ensure the quality of the test instrument is imperative (Palumbo & Reed, 1988; Roblyer, 1988) to enable the consumer to gain a sense of the thoroughness of the product and gain confidence to use the supplied instrument.

These guidelines are appropriate for any type of learning environment and are not unique to computer based learning. However, the computer is especially suited to meet these specifications for a number of reasons. A major advantage of using computers is their infinite patience to wait for a student to absorb information and formulate responses--a luxury seldom available in traditional settings. The consistency provided by computer based instruction ensures that all learners receive the same level, quantity, and quality of assessment procedures. Computers can also provide practice and performance situations that resemble or closely represent "real" situations through simulations.

Providing Feedback

Providing students with information about their own learning facilitates performance (Jonassen & Hannum, 1987), therefore, computer based learning activities should be designed to require learner responses and provide feedback on those responses indicating correctness in a positive and informative, but not entertaining manner (Aronson & Briggs, 1983). Although some researchers have reported no differences in learning when different types of feedback are used

(Canino & Cicchelli, 1988; Sales & Williams, 1988; Schloss, Wisniewski & Cartwright, 1988), presenting some sort of feedback is better than none at all (Keller & Suzuki, 1988; Scholss, Wisniewski & Cartwright). There are four basic types of feedback: (a) simple yes/no, (b) correct answer feedback--yes/no plus the correct answer, (c) explanatory--brief or lengthy explanations, and (d) bug-related--points out logic errors (Schimmel, 1988). These four feedback types lie on a continuum from least to most useful for learning enhancement.

Types of Feedback

Correct/Incorrect. Simple yes/no type feedback may be acceptable for rote recall items (Merrill, 1983), but even when presented as flashy cartoon graphics do not enhance motivation or achievement (Surber & Leader, 1988). Similarly, simple positive comments interspersed throughout a lesson do not produce higher levels of motivation (Jonassen & Hannum, 1987). The use of simple yes/no feedback should be avoided.

Correct answer. The second type of feedback--correct answer--presents the correct answer to the learner in addition to confirming a correct or incorrect response, and is the most supported type of feedback (Jonassen & Hannum, 1987; Merrill, 1983; Schimmel, 1988). Since little is needed to include the correct answer when informing learners they did or did not answer correctly, this should be the minimum level of feedback used in computer based learning.

Explanatory. The third level of feedback--explanatory--is appropriate for intellectual skills development by (a) identifying errors, (b) providing guidance towards the correct response, and (c) giving praise for correct answers (Schimmel, 1988). When errors are detected they should be corrected according to the following four priorities: (a) errors before omissions, (b) prior steps before later steps, (c) shorter fixes before longer fixes, and (d) more important factors before less important factors (Collins & Stevens, 1983). Providing guidance and giving praise also functions as a motivational strategy by increasing learners' intrinsic satisfaction with the instruction by attributing success in the learning task to the student (Keller, 1983; Merrill, 1983).

Bug related. The fourth level of feedback--bug-related--corrects the student by directly addressing the specific procedural errors being committed (Schimmel, 1988). This type of feedback is dependent on the computers ability to identify the error(s) being made by the student

which in practice is extremely difficult due to learner inconsistencies and the complexity of a program that contains bug libraries or sets of rules that match all possible student errors.

Other Feedback Issues

Feedback Control. When learning involves intellectual skills and the target audience is high achievers, Schimmel, (1988) suggests that the student or program should choose the appropriate type of feedback because high ability students generally use feedback more constructively than low ability students who may choose a level that gives answers rather than promotes thinking skills. Ideally, the program should control the feedback type based on user performance, but high ability students will probably choose an appropriate level if presented with a menu or the option to access different levels within the program.

Timing. The timing of feedback delivery can have differential effects on learning and motivation (Keller, 1983). Immediate feedback is more effective than delayed feedback for tasks in which students are required to make decisions and when new information is first learned (Jonassen & Hannum, 1987) and also motivates students to maintain the quantity of responses (Keller). On the other hand, to increase the quality of performance, Keller recommends that corrective feedback be given when it will be immediately useful--usually just before subsequent opportunities to practice. End-of-session feedback is important when the learning task involves abstract concepts, especially for higher achieving learners (Jonassen & Hannum).

Relevance to content and learner. Feedback should be related to the content of the lesson. For example, using money type rewards for tasks not related to money, or arbitrary point systems generally do not motivate students to perform better (Keller, 1983). However, interjection of unexpected, non-contingent rewards rather than anticipated rewards to heighten motivation levels is often useful, but only if they are used prudently and judiciously (Jonassen & Hannum, 1987; Keller).

Another extremely motivating feedback strategy is the use of attributional feedback which attributes learners' responses to their own learning strategies (Keller). This technique helps students connect their success to personal effort and ability.

Feedback for low achievers. Low achievers need more feedback than average or above average learners (Blanchard, 1987; Schimmel, 1988). The low achiever classification

includes students with learned helplessness--a state in which competent learners attribute their lack of achievement to an inability to achieve (Keller, 1983). Although important for all learners, the use of feedback that will encourage low achievers by focusing on the correct portions of answers that are not completely right and by using attributional feedback is especially important. Two more help strategies are: restating difficult questions in different forms to help the student with the answer or tie the answer back to the original concept (Merrill, 1983) and providing pre-response help or elaboration that gives relevant information to help the student answer the question (Merrill).

Feedback Summary

Learning needs to be verified in most situations by comparing student performance with criterion performance while ascending the learning hierarchy. When performance is assessed, learners need to be informed of their successes or failures through feedback. How the feedback is presented can facilitate or debilitate further learning. The principles discussed above are largely within the scope of contemporary computer based instruction. Courseware can be designed to provide adaptable feedback based on learner responses and also recognize responses that are not entirely correct due to faulty typing.

Other Design Issues

Thus far the discussion has included instructional design theories and techniques that, although especially suited for computer based instruction apply to all learning regardless of the delivery mode. However, with the computer's high potential for presenting efficient, interesting, and adaptable instruction comes other inherent issues that affect courseware design. Learner control, fear reduction, cuing, mnemonics, and personalization are often part of a classroom teacher's automatic professional routine but they become important issues when designing computer based instruction.

Learner Control

Computers can provide opportunities for learners to decide what lessons to pursue at any given time, how many questions to answer and how much time to spend on particular parts of a lesson. This control over a lesson is often touted by software companies as a reason learners will work harder and achieve more. Studies have been conducted to determine how much learner control is in fact advantageous to the learning process.

Many studies that examined the effects of learner control showed no achievement differences between students who (a) had control over program sequence and (b) those who were forced to follow a given linear path (Canino & Cicchelli, 1988; Hannafin & Colamaio, 1987; Hines & Seidman, 1988; Tennyson & Buttrey, 1980). There are also examples that show positive effects on achievement (Gay, Trumbull & Smith, 1988) and some that show negative effects (Hooper & Hannafin, 1988) due to learner control. Reigeluth and Stein (1983) assert that only simple to complex sequences allow learners to make informed decisions about sequence and therefore learner control should be incorporated into the various elaboration theories whenever possible, but only if the learners are properly instructed in the effective use of control strategies. One way to accomplish this is through formatting options: the instructional components should be clearly identified and separated to facilitate learners' selection and sequencing according to their needs and interests--most commonly through menu driven programs (Keller & Suzuki, 1988). Knowledge structure enhancement devices should also be presented to enhance learners' competency of use and to stimulate informed interaction with the content including stimulating review and study strategies (Jonassen & Hannum, 1987; Reigeluth & Stein).

Jonassen and Hannum (1987) maintain that it is not effective to give learners control over (a) instructional method, (b) amount of instructional support, (c) specific instructional events, (d) instructional sequence, or (e) difficulty of practice items. However, there are other important variables to consider besides achievement: (a) attitude, (b) learner ability, (c) time on task, and (d) pacing.

Attitude. Students' attitudes can be affected by the amount of control they have over the lesson. Students able to choose their own program sequence have more positive attitudes than students with no control over sequence (Milheim, 1989). Also, expectations for success can be increased by providing opportunities for choice, responsibility and control that reflects and supports internal attributions for success (Jonassen & Hannum, 1987; Keller, 1983). In a study comparing groups of students blocked as (a) field independent or (b) field dependent in either (a) a linear program sequence group (no learner control) or (b) guided discovery design group, field independent students preferred the discovery approach even though their achievement levels were the same for both types of program control (Canino & Cicchelli, 1988). Therefore, the problem is:

students with control over the lesson have better attitudes but usually achieve less or, at best, an equivalent amount as when they do not have control. Research on this problem has led to an answer: Courseware can be constructed to give the learner control over program sequence and branching opportunities, but instead of leaving the choice completely to the user, the program should offer advisement based on pedagogy or, in more complex programs, based on student performance to show learners the ideal path through the learning task (Jonassen & Hannum; Ross & Morrison, 1988; Tennyson, 1984). In a study by Hannafin and Colomaio (1987) in which students had (a) control over the program, (b) no control over the program, or (c) control with advisement, students with control and advisement almost always followed the computer's advice and students with control but no advisement skipped steps and performed more poorly than the advisement group. The no control group and the advisement group performed equally but the advisement group had a more positive attitude towards the lesson.

Learner ability. The advisement strategy also compensates for the problem of program suitability for learners with different ability levels. Lower level learners and students who have limited prior knowledge about a learning task are generally poor judges of their learning needs (Hooper & Hannafin, 1988). Also, high-level learners usually select too much support and low-level learners usually select too little (Ross & Morrison, 1988). These students will likely not perform well if they have control over the program, but will usually follow advice regarding program sequence if given, but higher level students and those with some previous knowledge can still skip parts of the program they already know. Therefore, a program with advisement can be used for a wider range of learners.

Time on task. Another issue regarding learner control is time on task. Again, students in a learner control verses advisement strategy produced equal achievement, but the advisement group completed the lesson in less time because they were advised to move on as soon as they reached criterion level for a particular concept (Tennyson & Buttrey, 1980).

Lesson pace. A final aspect of learner control in computer learning is the obvious advantage of students proceeding at their own pace. The computer is infinitely patient and students prefer their own pacing (Milheim, 1989). However, student pacing may not always be appropriate: the program may be teaching or practicing a skill that must be performed quickly, such

as developing automaticity of response, or quick assessment and decision making. In these types of time critical situations, computer pacing is appropriate.

Teaching Tools

Anxiety reduction. Anxiety is an affective phenomenon which has long been considered an influential factor in education. Anxiety can be caused by exposure to new material, new teachers or new technologies and manifests itself in a variety of emotional and/or physiological forms, either real or imagined (Wicks, 1977). According to Wicks, the best way to overcome anxiety and consequently reduce the detrimental effects on learning is by relaxation, reassurance, and learning to overcome the fear that causes anxiety. Well designed instructional sequences include the use of orienting activities (if deemed necessary) and accurately identify the appropriate starting state of the learner which will lead to student reassurance by increasing their expectations of success (Keller, 1983).

Because anxiety resulting from initial exposure to computer technology can be significantly reduced in as little as six hours of introductory instruction (Overbaugh & Reed, 1991) activities designed specifically to familiarize students with the computer as a tool may be useful. Another way to help reduce anxiety is by permitting group work and using shared sum scoring, although specific task assignments for each group member is important (Keller).

Cuing. Cues refer to instructional devices employed to direct the learners' attention to certain points or relationships in remember or use type content, either through screen design or text. Screen based cues are the use of highlighting, color, arrows, underlining, shading and moving text to focus learners' attention on particular points (Jonassen & Hannum, 1987; Merrill, 1983). Text based cues are explanations that clarify or elaborate on relationships or associations between concepts and examples. Both types of cues should be slowly faded as the student learns more about the concepts to avoid dependency (Gropper, 1983).

Mnemonics. Mnemonics can be employed to help students with rote recall tasks (Jonassen & Hannum, 1987; Merrill, 1983). The computer is able to present various strategies such as peg words, acronyms, stories using key words or facts, and key letter sentences. Even better, the courseware can assist the learner in constructing and using their own mnemonics by

providing a "note pad" window in which students can create and save their mnemonics for later use.

Personalization. A technique for increasing interest and motivation is the use of personalization within the program (Jonassen & Hannum, 1987) by including the students names and, if possible, information about their backgrounds and interests which will be integrated with the program presentation. This technique has been successful with elementary age children learning abstract concepts but should be faded because the novelty wears off (Ross & Morrison, 1988).

Pre-programming Development

Clearly, the first stage--instructional design--is the most time consuming, encompassing and rigorous task of courseware developers. Once this stage is completed, the job is essentially complete except for converting all the planning into an actual piece of courseware. The second step--preprogramming development--involves only three steps: (a) creating flow charts and story boards to aid in the actual programming, (b) developing all support materials for the courseware, including any supplemental instructional materials, and (c) reviewing all instructional and support materials before the actual programming begins (Roblyer, 1988).

Programming

The final stage is the relatively straightforward task of actually programming the courseware by a programmer. The instructional designer and the programmer should work together during programming, including first draft evaluation and revisions (Roblyer, 1988).

Bibliography

Anderson,, R.C., Spiro, R.J., & Anderson, M.C. (1978). Schemata as scaffolding for the representation of information in connected discourse. *American Educational Research Journal, 15,* 433-440.

Aronson, D.T. & Briggs, L.J. (1983). Contributions of Gagne and Griggs to a prescriptive model of instruction. In C.M. Reigeluth (Ed.), *Instructional-Design Theories and Models*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Blanchard, J.S. (1987). Instructional design issues in computer-based reading: Reinforcement and objectives. *Computers in the Schools, 4*(1), 25-35.

Canino, C. & Cicchelli, T. (1988). Cognitive styles, computerized treatments on mathematics achievement and reaction to treatments. *Journal of Educational Computing Research, 4*(3), 253-64.

Carrier, C.A. (1988). Adapting courseware to accommodate individual differences. In D. H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Collins, A. & Stevens, A.L. (1983). A cognitive theory of inquiry teaching. In C.M. Reigeluth (Ed.), *Instructional-Design Theories and Models*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Denenberg, S.A. (1988). Semantic network designs for courseware. In D. H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Gagne, R.M. (1975). *Essential of learning for instruction.* New York: Holt, Rinehart and Winston.

Gagne, R.M. (1986). Instructional technology-the research field. *Journal of Instructional Development, 8*(3), 7-14.

Gagne, R.M., & Briggs, L.J. (1979). *Principles of instructional design (2nd ed.).* New York: Holt, Rinehart and Winston.

Gay, G., Trumbull, D. & Smith, J. (1988). Perceptions of control and use of control options in computer-assisted video instruction. *Tech Trends, 33*(5), 31-33.

Gropper, G.L. (1983). A behavioral approach to instructional prescription. In C.M. Reigeluth (Ed.), *Instructional-Design Theories and Models*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Hamilton, R.J. (1985). A framework for the evaluation of the effectiveness of adjunct questions and objectives. *Review of Educational Research, 55*(1), 47-85.

Hannafin, M.J. & Colamaio, M.E. (1987). The effects of variations in lesson control and practice on learning from interactive video. *Educational Communication and Technology Journal, 35*(4), 203-12.

Hannafin, M.J., Garhart, C., Rieber, L.P. & Phillips, T.L. (1985). Keeping interactive video in perspective: Tentative guidelines and cautions in the design of interactive video. In E. Miller and M.L. Mosely (Eds.) *Educational Media and Technology Yearbook*. Littleton, CO: Libraries Unlimited.

Hannafin, M.J. & Hooper, S. (1988). *Empirically-Based Guidelines for Designing Interactive Video*. Paper presented at the 1988 meeting of the American Educational Research Association, New Orleans, LA.

Hannafin, M.J. & Peck, K.L. (1988). *The design, development and evaluation of instructional software*. New York: Macmillan Publishing Company.

Hannafin, M.J., Phillips, T.L. & Tripp, S.D. (1986). The Effects of Orienting, Processing, and Practicing Activities on Learning from Interactive Video. *Journal of Computer-Based Instruction, 13*(4), 134-39.

Hannum, W. (1988). Designing courseware to fit subject matter structure. In D. H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Hativa & Teper, (1988). Differential effectiveness of three color treatments in learning geometric concepts via computer-guided teaching. *Journal of Educational Computing 4*(3), 303-20.

Hines, S.J. & Seidman, S.A. (1988). *The Effects of Selected CAI Design Strategies On Achievement, and An Exploration of Other Related Factors*. Paper presented at the 1988 Annual Meeting of the Association for Educational Communications and Technology, New Orleans, LA. ERIC Document Reproduction Service No. 295-650.

Jonassen, D.H. (1988). Integrating learning strategies into courseware to facilitate deeper processing. In D. H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Jonassen, D.H., & Hannum, W.C. (1987). Research-based principles for designing computer software. *Instructional Technology, December,* 7-14.

Kanner, J.H. (1968). *The instructional effectiveness of color in television: A review of the evidence*. Stanford: Stanford University (ERIC Document Reproduction Service No. 015-675).

Keller, J.M. (1983). Motivational design of instruction. In C.M. Reigeluth (Ed.), *Instructional-Design Theories and Models*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Keller, J.M. & Suzuki, K. (1988). Use of the ARCS motivation model in courseware design. In D. H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Landa, L.N. (1983). The algo-heuristic theory of instruction. In C.M. Reigeluth (Ed.), *Instructional-Design Theories and Models*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Mayer, R.E. (1984). Aids to text comprehension. *Educational Psychologist, 19,* 30-42.

Merrill, M.D. (1983). Component display theory. In C.M. Reigeluth (Ed.), *Instructional-Design Theories and Models*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Merrill, M.D. (1988). Applying component display theory to the design of courseware. In D. H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Merrill, P.F., & Bunderson, C.V. (1979). *Guidelines for employing graphics in a videodisk training system. ISD for videsdisc training systems*. (ERIC Document Reproduction Service No. 196-413).

Milheim, W.D. (1989). *Perceived Attitudinal Effects of Various Types of Learner Control in an Interactive Video Lesson.* Presented at the 1989 meeting of the Association for Educational Communications and Technology, Dallas, TX. ERIC Document Reproduction Service No. 308-828.

Montague, W.E. (1988). Promoting cognitive processing and learning by designing the learning environment. In D. H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware.* Hillsdale, N.J.: Lawrence Erlbaum Associates.

Overbaugh, R.C. & Reed, W.M. (1991). *The effects of prior experience and instructional format on teacher education students' computer anxiety and performance.* Paper presented at the 1991 Annual Meeting of the American Educational Research Association, Chicago, Illinois.

Palumbo, D.B. & Reed, W.M. (1988). A microcomputer-based evaluation subsystem for the textual component of an instructional system. *Journal of Educational Computing Research, 4*(2), 167-83).

Phillips, T.L., Hannafin, M.J. & Tripp, S.D. (1988). The effects of practice and orienting activities on learning from interactive video. *Educational Computing and Technology Journal, 36*(1), 93-102.

Reeves, T.C. (1986). Research and evaluation models for the study of interactive video. *Journal of Computer-Based Instruction, 13*(4), 102-106.

Reigeluth, C.M., & Stein, F. S. (1983). The elaboration theory of instruction. In C.M. Reigeluth (Ed.), *Instructional-Design Theories and Models.* Hillsdale, N.J.: Lawrence Erlbaum Associates.

Roblyer, M.D. (1988). Fundamental problems and principles of designing effective courseware. In D. H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware.* Hillsdale, N.J.: Lawrence Erlbaum Associates.

Ross, S.M. & Morrison, B.R. (1988). Adapting instruction to learner performance and background variables. In D. H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware.* Hillsdale, N.J.: Lawrence Erlbaum Associates.

Salisbury, D. (1988). Effective drill and practice strategies. In D. H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Scandura, J. M. (1983). Instructional strategies based on the structural learning theory. In C.M. Reigeluth (Ed.), *Instructional-Design Theories and Models*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Schimmel, B.J. (1988). Providing meaningful feedback in courseware. In D. H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Surber, J.R. & Leeder, J.A. (1988). The effect of graphic feedback on student motivation. *Journal of Computer-Based Instruction, 15*(1), 14-17.

Tennyson, R.D. (1984). Artificial intelligence methods in computer-based instructional systems: The Minnesota Adaptive Instructional System. *Journal of Instructional Development, 7*(3), 17-22.

Tennyson, R.D., & Buttrey, T. (1980). Advisement and management strategies as design variables in computer-assisted instruction. *Educational Communications and Technology Journal, 28*, 169-76.

Wager, W. & Gagne, R.M. (1988). Designing computer-aided instruction. In D. H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware*. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Wicks, R.J. (1977). *Counseling strategies and intervention techniques for the human services*. Philadelphia: J.B. Lippincott Company.